

What I claim is:

1. A current transformer, comprising:

a Rogowski coil, having an opening at the center in which a conductor penetrates, comprising:

a printed circuit board having a plurality of layers forming at least first to fourth circuit board surfaces including a circuit board top surface, a circuit board bottom surface and circuit board conducting internal surfaces between the circuit board top surface and the circuit board bottom surface;

a plurality of radial metal foils, each metal foil radiating from a center that is approximately the center of the opening, mounted on the first to fourth circuit board surfaces;

a first winding formed by electrically connecting metal foils on the first and second circuit board surfaces with first plated through holes penetrating the first and second circuit board surfaces in a thickness direction of the printed circuit board;

a second winding formed by electrically connecting metal foils on the third and fourth circuit board surfaces with second plated through holes penetrating the third and fourth circuit board surfaces in a thickness direction of the printed circuit board;

a first return circuit line electrically connected with the first winding in series;

a second return circuit line electrically connected with the second winding in series; and

a pair of the first winding and the first return circuit line and a pair of the second winding and the second return circuit line being electrically connected in series.

2. The current transformer in Claim 1, wherein the first return circuit line and the second return circuit line are first and second circular metal foils with a center that is the center of the opening.

3. The current transformer in Claim 2, wherein a number of a plurality of windings, including the first winding and the second winding, equals to a number of a plurality of return circuit lines, including the first return circuit line and the second return circuit line, and the second return circuit line is formed on the same circuit board surface.

4. The current transformer in Claim 2, wherein a number of a plurality of windings, including the first winding and the second winding, equals to a number of a plurality of return circuit lines, including the first return circuit line and the second return circuit line, and the first return circuit line is formed on a fifth circuit board surface of the plurality of layers, and the second return circuit line is formed on a sixth circuit board surface of the plurality of layers.

5. The current transformer of claim 1, wherein the first circuit board surface is the circuit board top surface, the second circuit board surface is a circuit board internal surface, the third circuit board surface is the circuit board bottom surface, and the fourth circuit board surface is a circuit board internal surface.

6. The current transformer of claim 1, wherein the first circuit board surface is the circuit board top surface, the second circuit board surface is the circuit board bottom surface, the third circuit board surface is a circuit board internal surface, and the fourth circuit board surface is a circuit board internal surface.

7. The current transformer in Claim 1, wherein the Rogowski coil comprises:

N windings, including the first and second windings, each formed by electrically connecting the radial metal foils on a respective pair of the circuit board surfaces with plated through holes penetrating the pair of circuit board surfaces in a thickness direction of the printed circuit board, N being an integer greater than one;

N return circuit lines, including the first and second return circuit lines; each return circuit line being formed on at least one of the circuit board surface; and

the N windings and the N return circuit lines being electrically connected in series.

8. The current transformer in Claim 7, wherein each of the N return circuit lines is a return winding formed by electrically connecting radial metal foils on a respective pair of the circuit board surfaces with plated through holes penetrating the pair of circuit board surfaces in a thickness direction of the printed circuit board, and is wound in a direction opposite to a direction in which the N windings are wound;

9. The current transformer in Claim 8, wherein the Rogowski coil further comprises:

a first multiple winding formed by connecting a first group of the windings to each other in series; and

a second multiple winding formed by connecting a second group of the return windings to each other in series,

wherein the first multiple winding and the second multiple winding are connected to each other so that the first multiple winding is a mirror image of the second multiple winding on the printed circuit board.

10. The current transformer in Claim 1, wherein the plurality of layers including  $(4 \cdot N + 2)$  circuit board surfaces, on each of which the plurality of radial metal foils are formed, N being an integer not smaller than one, and a fifth circuit board surface, and wherein the first return circuit line is a first circular metal foil on the fifth circuit board surface with a center that is approximately the center of the opening, and wherein the Rogowski coil further comprises:

$(N+1)$  windings, including the first and second windings, each winding being formed by electrically connecting the radial metal foils on a respective pair of the circuit board surfaces with plated through holes penetrating the pair of circuit board surfaces in a thickness direction of the printed circuit board;

N return circuit lines, including the second return circuit line, each return circuit line being a return winding formed by electrically connecting radial metal foils on a respective pair of the circuit board surfaces with plated through holes

penetrating the pair of circuit board surfaces in a thickness direction of the printed circuit board, and being wound in a direction opposite to a direction in which the (N+1) windings are wound; and

the (N+1) windings, the N return windings, and the first circular metal foil being electrically connected in series.

11. The current transformer as recited in Claim 1, wherein the Rogowski coil comprises a plurality of the printed circuit boards, arranged so that corresponding center axis openings of respective printed circuit boards are aligned with each other, and the windings formed on the respective printed circuit boards are connected to each other in series.

12. The current transformer in Claim 1, further comprising:

a sensor unit, comprising,

an analog-to-digital converter which converts the analog-voltage signal into a digital electric signal, and

an electric-to-optic converter which converts the digital electric signal into a digital optical signal; and

an optical transmission unit which transmits the digital optical signal to upstream system.

13. The current transformer in Claim 12, wherein a number of the Rogoski coils, a number of the sensor units, and a number of the optical transmission units are each more than one, and the current transformer further comprises:

a merging unit which merges a plurality of the digital optical signals outputted from the respective Rogowski coils through the respective sensor units to generate at least one merged transmission signal, and transmits the merged transmission signal to the upstream system.

14. The current transformer in Claim 13, wherein the merging unit comprises:

a plurality of optic-to-electric converters, each of which converts the

respective digital optical signals into a second digital electric signal;  
a second merging unit which merges the respective second digital electric signals to generate at least one second electrical merged transmission signal; and  
a second electric-to-optic converter which converts the second electrical merged transmission signal into a second digital optical signal.

15. The current transformer in Claim 13, wherein the merging unit and the upstream system are connected through a point-to-point transmission channel.

16. The current transformer in Claim 14, wherein the merging unit and the upstream system are connected through a local area network.

17. A current transformer, comprising:  
a Rogowski coil, having an opening at the center in which a conductor penetrates, comprising:  
a printed circuit board having a plurality of layers forming at least  $2N+1$  circuit board surfaces including a circuit board top surface, a circuit board bottom surface and circuit board internal surfaces between the circuit board top surface and the circuit board bottom surface, N being an integer more than one;  
N windings, each formed by electrically connecting the radial metal foils on a respective pair of circuit board surfaces with plated thorough holes penetrating the pair of circuit board surfaces in a thickness direction of the printed circuit board; and  
a return circuit line formed on a circuit board surface, electrically connected with at least one of the N windings in series.

18. The current transformer in Claim 17, wherein the return circuit line is a circular metal foils with a center that is approximately the center of the opening.

19. The current transformer in Claim 17, wherein the return circuit line is set between two of windings, and at least one of the N windings and the return circuit line are electrically connected in series.

20. The current transformer in Claim 17, wherein the Rogowski coil further comprises:

a first multiple winding formed by connecting a first group of windings to each other in series;

a second multiple winding formed by connecting a second group of windings to each other in series,

wherein the first multiple winding and the second multiple winding are connected to each other so that the first multiple winding is a mirror image of the second multiple winding on the printed circuit board.

21. A current transformer, comprising:

a Rogowski coil, having a opening at the center in which a conductor penetrates, comprising:

a printed circuit board having a plurality of layers forming at least  $2N$  board surfaces including a circuit board top surface, a circuit board bottom surface and circuit board internal surfaces between the circuit board top surface and the circuit board bottom surface,  $N$  being an integer greater than one; and

$N$  windings, each formed by electrically connecting the radial metal foils on a respective pair of circuit board surfaces of with plated through holes penetrating the pair of circuit board surfaces in a thickness direction of the printed circuit board,

wherein the  $N$  windings are connected in series.

22. The current transformer in Claim 21, wherein a first one of the  $N$  windings is wound in a direction opposite to a direction in which a second one of the  $N$  windings is wound.

23. The current transformer in Claim 21, wherein one of the  $N$  windings is set between two other ones of the  $N$  windings.